HIGH-SPEED FLIGHT RESEARCH

Concluding Part of Mr. H. Davies' Lecture Before the R.Ae.S.

Continued from page 333, March 25th

Stability and Control

The earliest experiences of compressibility effects on the longitudinal characteristics of an aircraft were concerned with the large and often dangerous changes of trim which occurred in high-speed dives, and a number of measurements of these effects were made (Fig. 7).

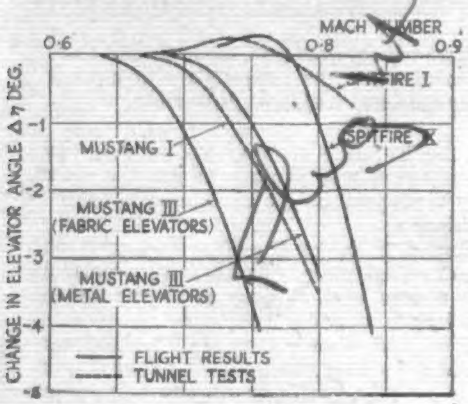


Fig. 7. Spitfire and Mustang. Change of elevator angle with Mach number, measured relative to elevator angle to trim for "Ig." at same E.A.S. at low Mach number.

That these effects really were due to compressibility and not to aeroelastic distortion in these cases is shown by Fig. 8. At 10,000ft there is practically no change in elevator angle to trim up to an equivalent air speed of 450 m.p.h. At 30,000ft, however, there is a large change at below 350 m.p.h. E.A.S. We are not, of course, always favoured with such an absence of distortion effects. In the case of the Me.262, for example (Fig. 9), as you see the compressibility effect is more than offset at low altitude by distortion, which greatly complicates any attempt to analyse the overall effects.

The change of trim at high Mach number is the result of a combination of compressibility effects on C_{mo}, aerodynamic centre, $\frac{\delta C_L}{\delta\alpha}$ and ϵ. It is difficult to separate out these effects in flight, though attempts have been made to do this by measuring the tail loads by means of strain gauges.

Stability

These changes of trim imply changes in longitudinal stability. Unfortunately, it is difficult to derive precise conclusions regarding the stability changes from dive tests, because the lift coefficient is necessarily very small throughout the dive. This is one of the fundamental weaknesses of the dive technique. Luckily, however, the rapid development of jet engines has enabled sufficiently high speeds to be achieved now to investigate these effects in level flight.

In this case (Figs. 10 and 11) the static margin was slightly negative at low speeds. At a Mach number of 0.8 the negative static margin suddenly becomes extremely large, at all heights. The stick-free static margin behaves similarly.

It is not at all certain, at the present state of our knowledge, how important such a large reduction in static margin is at high speeds. It is probably not nearly as important as such a change would be at low speeds.

What is undoubtedly important at high speeds, however, is any variation in the slope of the curve of η (or C_m) against C_L, not for level flight, as in this diagram, but for constant Mach number.

The result is shown in Fig. 12. The slopes of these curves represent virtually the manœuvre margins, and as you see the variation is somewhat involved. The peculiar curve for $M=0.79$ is a little uncertain, but is, I think, roughly true. This is one of the few cases incidentally where comparison with tunnel tests is rather disappointing.

The next diagram (Fig. 13) shows the results of similar measurements on a Meteor IV. Here again there is a large loss in stick-fixed static margin at high speeds, but in this case there appears to be a large increase in stick-free static margin, for reasons which I will return to in a minute. In the meanwhile, notice that when the tab angle to trim is plotted against Mach number, the result is a unique curve.

In this case there is a steady decrease in $\left(\frac{\delta\eta}{\delta C_L}\right)_m$ with increasing Mach number. Even at a Mach number of 0.75, there is

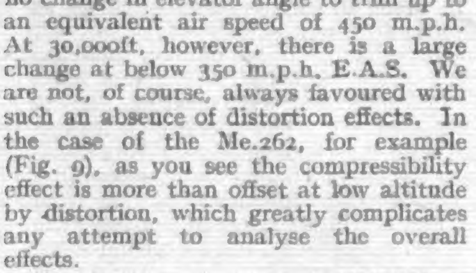


Fig. 8. Mustang. Elevator angles to trim at high speeds at two altitudes.

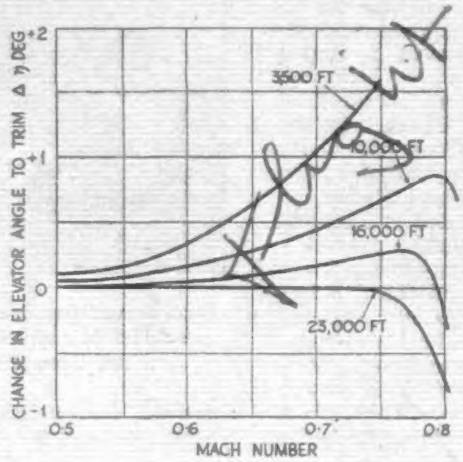


Fig. 9. Mach number and distortion effects on elevator angle to trim Me 262.

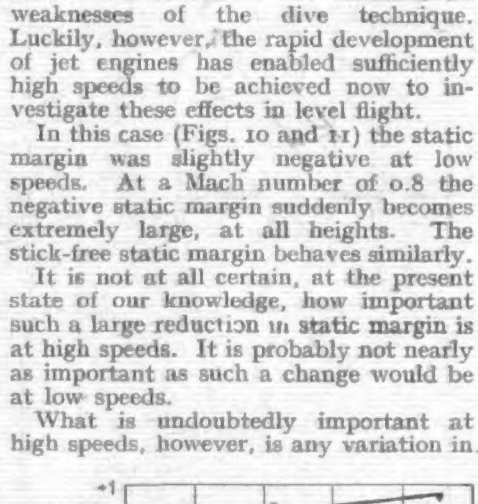
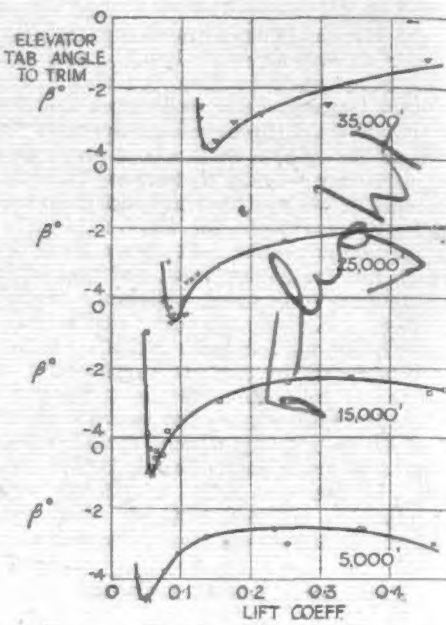


Fig. 10. Vampire I. Elevator angles to trim.



No. 11. Vampire I. Elevator tab angles to trim.

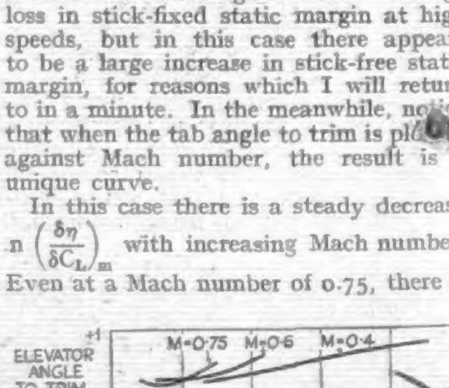


Fig. 12. Vampire I. Elevator angles to trim. Flight results shown above, tunnel results below.